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ABSTRACT

When computers first became available, scholars in the humanities made little use of them. Language applications were introduced by non-linguists. By contrast, numerical applications were pursued widely in the physical sciences, engineering, and business. Only recently have computer languages and hardware been developed for managing human language, accompanied by linguistic activities supported primarily by commercial interest in machine translation. However, the computer languages were not designed by linguists, and use logical conventions rather than natural language structures. Continued lack of attention to this technological advancement by specialists in language and increasing pressure for applications are leading to inadequate products. If specialists in the humanities do not participate in the development of software and systems, they will continue to be unsuccessful. Imaginative applications are now possible in areas such as the teaching of language and cultures, but they require the expertise of linguists to be useful. (Author/MSE)

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# FOUR DECADES WITH THE COMPUTER

Winfred P. Lehmann

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When computers first became available, scholars in the humanities made little or no use of them. Language applications, such as machine translation, were introduced by non-linguists. By contrast, numerical applications were broadly pursued; hardware and software were rapidly developed for numerical analysis and applications in the physical sciences, engineering, and the business world.

Only recently have computer languages and special computers been developed for managing human language, accompanied by linguistic activities supported primarily by commercial interest in machine translation. The languages were not designed by linguists, and were framed in accordance with logical conventions rather than natural language structures. While more advantageous than the languages designed for numerical processing, they are less congenial for human communication with computers than natural languages would be. Use of these for communication with computers is a widespread interest.

Continued lack of attention by specialists in language, and increasing pressures for applications, are leading to inadequate products, as for computerized language teaching. If specialists in the humanities do not participate in such activities, these will again be unsuccessful. Possibilities are now opening for imaginative applications, as in the teaching of languages and cultures. Humanists concerning themselves with applications will advance their field, while providing greatly improved teaching capabilities with the help of computerized devices.

The title of my paper might lead humanists to expectations of anecdotes about Lord Byron, more probably about his gifted daughter, Ada Lovelace, reputed to be the first programmer. Actually, the kind of computer I first ran into was not unlike hers, or Babbidge's. During World War II, I had the fortune of belonging to a unit whose activities we were never to talk about subsequently, a unit then named the Second Signal Service Battalion. My wing of that unit was concerned with the translation of Japanese documents. Even at that time the usefulness of computers was recognized, as an incident may indicate.

In the early days of our activities there were no handbooks for the type of Japanese with which we were concerned, a type we came to call the Formal Written

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Style. There were no dictionaries for it either. But there were rows and rows of machines and printout after printout of Japanese texts. Some ingenious planner made a run of a large number of texts and printed out the words by their frequency. Equipped with this information, our bank of three teachers made an appointment with their Navy counterparts to discuss plans for cooperation in producing the desired handbooks. The Navy Commander in question was dubious about the value of the computer list. To bring him around, the senior Army instructor said that without the information from the computer one might produce a handbook including words like *hoorensoo*. To which the Navy Commander replied: "*Hoorensoo, hoorensoo*, we see that word in our texts all the time." Since *hoorensoo* is the Japanese word for "spinach," the Army group quickly said their farewells and proceeded to prepare their handbooks independently. Only toward the end of the war, when personnel waiting for discharge had few duties, was liaison established with our Navy counterparts.

Four decades ago and even earlier, then, the mechanical computer was useful for specific purposes in the treatment of language. When the first electronic computer, one foot longer than Beowulf's dragon, replaced its mechanical ancestor toward the end of the war, similar uses were proposed for it. The computer is a symbol-manipulating device. Human beings make use of two elaborate systems of symbols: numbers and language. As a manipulator of symbols the computer might deal with either. In proclaiming the capabilities of the new machine, its major proponents recognized these possibilities. Warren Weaver suggested that among its applications was computerized translation, usually called machine translation.

Few probably need convincing that the pragmatic society of today, for all its praise of pure research, demands applications in providing support for scholarly ventures. Physicists may have gloried in their concentration on uncovering the laws of the universe but, apart from the attention paid to one of them annually by the Nobel Foundation, they occupied offices in dim corners of science buildings before advent of the atomic bomb. However much they may proclaim dissociation from applications involving atomic study, few have maintained idealistic attention to pure research, as the proportion of particle to acoustic physicists may demonstrate. In the human sciences, on the other hand, the lure of study untainted by the promise of practical results lives on, probably at least in part because there are no billions pouring out of Washington.

Unlike physical scientists and such social scientists as economists, linguists and other humanists did not concern themselves with computers as they became available, let alone develop new uses for them. Major figures taking up Warren Weaver's challenge, such as Léon Dostert of Georgetown University and Victor Yngve of MIT, did not emerge from linguistics. They and others who joined them concentrated on machine translation, in a manner much like the earlier use of mechanical computers for dealing with language. Matching allowed the

identification of the string *hoorensoo* among numerous other Japanese strings. With slightly different procedures this string could be matched with a designated string (for example *spinach* or *Spinat*) in a different language. Only slowly did the computational specialists concerned with language move from lexical matching to syntactic and semantic analysis. Linguists showed little interest in the action, rather disdain.

By contrast, the users concentrating on numerical symbols made huge advances. For their simpler symbolic system, speed of manipulation was important. Accordingly, hardware was developed so that the symbols concerned could be processed with ever-increasing speed. By contrast, hardware was not being developed for the differing requirements of language and data processing.

Similarly, procedures for access to the increased capabilities were developed. Instead of using machine language--long sequences written in the binary system of zeros and ones--so-called higher-level languages were produced. These came to be used, and developed further, in manipulating numerals for economic and business concerns as well as for study in the natural sciences.

One upgrade succeeded another, in hardware as well as software, until production of the fast mainframes of today with their high-level languages. Expense was no concern. When IBM unveiled its 360 series after a long, costly stage of development, it expended another huge sum on discovering the total inadequacy of its software. The sums expended in the subsequent decades may be gauged by looking at the standing of computer firms in the stock market.

What was happening in the meantime to applications in the other major symbolic system, or to attention to this symbolic system with the help of computers? The groups devoted to such research received small amounts of money, attended by high expectations. It is almost ludicrous to recall the publicity given Dostert's experiment carried out in connection with IBM to illustrate how machine translation might be instituted. A few Russian sentences with a vocabulary of a hundred or so items led *The New York Times* to proclaim success on its first page. And why not? Number crunchers were making good use of computers, and their pedigree was scarcely more venerable than that of linguists. The great intellectual center of Alexandria produced Dionysius Thrax a short time after Euclid, both before our era. Even earlier, Pāṇini was more advanced in his field than were the Indian mathematicians who gave us zero and the so-called Arabic numerals. Why shouldn't the specialists in the study of the linguistic symbolic system make comparable advances with those of specialists in the numerical symbolic system?

The answers are not hard to find. First, as noted above, the linguists were not interested. Their major figure of the time regarded language as an ideal system

located in an imagined organ of the brain, in a conception leading to abstract mapping of the functioning of that organ rather than attention to language. Second, language scholars in their humanistic tradition were completely unused to costly, large-scale activities. An undertaking of the American Academy of Arts and Sciences published less than a decade and a half ago a supposedly authoritative volume entitled *Language as a Human Problem*, in which one of the editors points to the solicited article whose author "discusses in some detail the débacle of machine translation which wasted millions of the taxpayers' dollars to little purpose and impeded the progress of serious research in the field" (Haugen & Bloomfield, 1974). The sum was "some $20 million on machine translation and closely related subjects...over the past 10 years" (National Academy of Sciences, 1966, p. 29). Even at that time the cost of one military aircraft was far greater than the total amount expended on machine translation. The amount is also considerably less than that required for a Cray X-MP machine. One result of the regard of humanists for adequate support is the discrepancy between the annual budget of NSF and that of NEH. Third, humanists were, and many remain, totally opposed to any attention to technological activities impinging on their area. The results of early machine translation were ridiculed. A day before this section was put on paper I once again heard an eminent humanist repeat the account of how the computer translated into Chinese the aphorism: "Out of sight, out of mind," which on retranslation appeared as "invisible idiot."

In the meantime the users of computers lumbered along with their succession of high-level languages, Fortran through its various upgrades, Cobol, PL-1, Ada, and so on. Visionaries would talk about the glorious future when there would be oral input, when the QUERTY keyboard would finally be deposited beside Whitney's cotton gin and McCormick's reaper in some recess of the Smithsonian Institution. But the visions stopped at that point, and for physical scientists they remained there. However attractive communication may be in the high-level language that human beings have developed, physical scientists, in their concern for harnessing computer technology, disregard it. Of a major funder we learn that it is DARPA's "strategic computing program" to break through "the conventional computing performance growth rate barrier of about 10% to 15% per year," and using hardware and software "achieve a factor of 1,000 improvement every three years" (Fisher, 1986, p. 84).

Moreover, an editorial appearing about a year ago in *Science* extolled the glories of the four National Centers for Supercomputing Applications, singling out the Beckman Institute (Abelson, 1985). Entitled "Computers and Interdisciplinary Research," the editorial lists the "supercomputing applications." We read of its "work stations with good computer graphics." Further, its "Intellectual Center...will bring together some of the nation's best physical and natural scientists and computer engineers, social scientists and computer professionals." In its "key objective..to foster interdisciplinary research...it will consist of two centers: a Center

for Materials Science, Computers, and Computation and a Center for Biology, Neuroscience, and Cognition." Inclusion of linguistics among the disciplines, to say nothing of the English Department, which presumably has some acquaintance with one of the human languages useful for computer input, apparently never occurred to Philip H. Abelson, Deputy Editor of *Science* for Engineering and Applied Sciences, nor to his colleague deputy editors, nor to his editor, nor to the long list of reviewing editors.

Before discussing the status of computer control of language today, we might note a recent statement recognizing its importance, in a book of Joseph Deken with the title *Silico Sapiens*, to which I return below. In his introductory chapter Deken says flatly: "Humans are no longer alone on earth as users and generators of language; computers joined us when the mathematician John von Neumann designed a machine that could remember and transform its own instructions." Deken goes on to warn about the "anthropomorphic trap" for anyone "watching a computer communicate in words (and nowadays even speak aloud)...." (1985/86, pp. 14-15). The computer's incipient control of human language apparently triggers the trap. Yet Deken may be too fearful, as those know who have tried the Kurzweil machines, one of which reputedly reads texts, the other of which understands speech. Anyone who has used them almost comes to believe in an ideal language, for they refuse to deal with such forms of texts as are produced by a dot-matrix printer.

Some of us have for some time "watched" computers like Gunnar Fant's Øve communicate not only in words but even in sentences. We have also seen the struggles to maintain research on human language, supported almost entirely by commercial interests, many concerned with machine translation. Information on the status of that research in 1985 may be obtained from Tim Johnson's book *Natural Language Computing: The Commercial Applications* (1985). Among other information we learn that projected sales of natural language processing applications in the United States will move from 15 million dollars in 1985 to 418 million in 1990 and to approximately 1500 million in 1995 (Johnson, 1986, p. 93). Further, the European Community has in operation a system which translates 350,000 words per hour. The system is known as Systran. Its fabricator, Peter Toma--originally chief programmer in Dostert's group at Georgetown University--last year sold Systran for $20 million, the sum which horrified the National Science Foundation and the National Academy of Sciences in 1963, and troubled the editors chosen by the American Acaademy of Arts and Sciences a decade later. A recent news release states that the Japanese-English version of Systran produces translation at the rate of 1.3 million words per hour.

Since the procedures of industrial applications are privileged information, I can give no details on the grammars and lexicons developed for these applications. Some machine translation systems, however, are less secretive. The procedures and requirements are after all straightforward. One may learn improved techniques or

ideas by examining other systems, just as General Motors can devise improved gimmicks after tearing a Nissan or a Porsche apart. But like any technological product, translation systems are complex affairs produced by dedicated experts who do not, and possibly cannot, modify one segment of their own product simply on discovering a new device in another. The new device may not fit into the existing scheme. Translation systems and their linguistic bases are not just thrown together, but carefully designed. Like the production of other components of the "(super-)computing development," such as its hardware and software, the production of the linguistic analyses necessary for communicating with computers through human language requires hard work by informed and talented scholars.

The situation can be equated with that arising when speakers of one language wish to communicate with speakers of another in a totally different culture. Linguists know the situation well. Non-linguists probably have run into accounts of it in the Pacific, as through Melville's novels. For such communication, a compromise language known as a pidgin was evolved. Communication with computers differs somewhat in that computers use a binary numeral system rather than a language of different structure. At first the human in the human-computer interchange made all the concessions. The human used the computer's language, so-called machine language. Finding it cumbersome because of the complex syntax necessary when the basic entities on which a language is built are only two, the human soon began constructing higher-level languages. These came to be increasingly like human language, especially when explicitly framed to approximate them, as are LISP and PROLOG. However high in level, they are still pidgins, or possibly by now creoles, since they come to be used by native computer-workers who do not first learn other programming languages. In accordance with the solution sketched, the computational society will proceed to use the highest-level languages, those developed among human social groups. Following the rhetoric of our colleagues, we may call human languages super-high-level languages. In time they may be replaced by so-called artificial languages at a still higher level; no such language has yet been devised.

Without denigrating the national language of Papua, or the common language of Haiti and others like them, we may regard pidgins as inadequate for all-purpose communication. Besides its status as a pidgin, LISP is a VSO language, scarcely the most-favored type. It makes great demands on its users, most of whom use SVO languages natively. McCarthy formed LISP in accordance with the arrangement that had been adopted in modal logic. The problems caused to their users by VSO languages may be indicated by the shift of these to SVO structure when they come into contact with other languages or are used by a wide array of speakers, as in Modern Hebrew. Whether such a shift will apply as further forms of LISP and PROLOG are devised remains to be seen. Whatever happens, LISP and PROLOG still make concessions to the machine.

Nonetheless greater ease for the human communicator has come with the application of such programming languages, and further with the production of LISP machines. Since their availability about six years ago, we have a favorable situation for language-processing activities. The situation will be almost explosively augmented with the availability of LISP chips, an advance announced by a major manufacturer of computer equipment for two years from the present. And connection machines, allowing parallel processing, should permit computer handling of language in accordance with its multiple structure, with vast improvement over current computers based on von Neumann's logic.

The availability of LISP machines and appropriate languages has speeded the production of large-scale grammars and dictionaries. Like the theoretical proposals of linguists since Jespersen and Koschmieder, these are based on formal systems. They are relatively complete for some languages at the sentence level. Further, some problems in discourse are handled, such as anaphoric relationships. But when languages like German, French, and even English have gender distinctions in anaphors, the problems of translation have only been skirted.

More adequate solutions depend on further semantic analysis. Entities in the lexicon initially had few descriptors, partly because of the demands on computer storage. Storage is now less troublesome than are the demands on lexicographers to determine appropriate semantic descriptors when these become increasingly delicate. Similarly, as grammars increase in size, the addition of new rules requires great care because any new rule may interfere with the application of more general rules. In spite of such problems, translations now produced by some systems are surprisingly good and well received. Some post-editors with long experience in dealing with translation by skilled human translators now evaluate translations by computer systems as superior, in part because of their consistency.

In noting such comments, we must be aware of the type of language texts involved. This is the language of manuals, precise to the point of dullness, as devoid as possible of any stylistic sparkle. Such texts are produced in hundreds of thousands of pages today to guide users of equipment far more complex than cameras with their manuals of fifty or so pages or minicomputers with manuals of several hundred pages. The manuals, however long, have to be ready when one installs an electricity generating plant or a telephone switching system in Brazil, Indonesia, or elsewhere, even in the United States. Concentration on the restricted language of such texts may provide a false idea of the complexity of the problem we have in dealing with human language through computers.

The danger of a simplistic conception of the problem is heightened by the reductionism in linguistics during the past century. The neogrammarians from 1875 or thereabouts restricted their attention largely to the least complex sub-systems of language, as did the structuralists. The generativists restricted their attention to an



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unreal language, in their words, an ideal language. Any attention to language as treated in the teaching of English, whether as a first or second language, or to language as examined in applied linguistics, must be directed at language as used by speakers in their social activities.

The damage to treatment of language by the reductionism of the major movements in linguistics during the past century is obviously complex, as will be the move to a more adequate treatment. Fortunately, there are now strong movements toward a new approach, away from reducing language to a system which is to be encompassed by procedures of mathematics or elementary logic. I cite only one study, an essay by Robert de Beaugrande to appear in the *Zeitschrift für Phonetik, Sprachwissenschaft und Kommunikationsforschung*. The essay is even longer and more complex than its title, which goes as follows: "Determinacy Distributions in Complex Systems: Science, Linguistics, Language, Life." In his final section Beaugrande makes the following statements about language as a dynamic code and about much of the work in linguistics:

> Each speaker has, like any system, a history with several dimensions: the cultural design of the society, the speaker's life, and his or her current actions and experiences. We might see a natural language as a complex system in which spoken and written texts manifest the coded aspect and the use of those texts the dynamic aspect. The problem of linguistics is that we have been analyzing the code in all sorts of ways, but seldom the dynamics of its use. (1987, p. 32)

Beaugrande does not cite Bakhtin, whose criticism of the partial attention which has dominated humanistic study is beginning to make an impact in all areas of humanistic study. Bakhtin sees language as "defining the relation between the self and the other," in a felicitous phrase of Joseph Frank (1986, p. 58). Language in this view is scarcely a code to be comprehended in a linguistic theory, however many sub-theories are proposed.

To deal with natural language adequately Beaugrande sketches activities which he calls "forbiddingly vast," requiring the design and exploration of many models of language "before we can narrow them down to a few plausible ones" (1987, p. 35). Recalling the attractions which model-proliferation seems to hold for linguists, a follow-up to Beaugrande's evaluation raises the possibility that linguists will once again sequester themselves in isolation, funded adequately only by standards which have been engrained among the bovine humanists. In the meantime, applications of computer manipulation of language will be left to non-specialists. I cite examples.

Software modules are alrady being marketed for language teaching, among other applications. They are universally poor. Produced by non-linguists, they are designed for the kind of large-scale market which brings appreciable financial

returns. Some even seek to teach the spoken language through the facilities of inexpensive minicomputers. Moreover, while we may say that funds for education are inadequate, even the poorest school districts are being equipped with such minicomputers. It does not require the services of a super-salesman to sell the available teaching modules to these schools. According to Joseph Raben, the well-known authority on uses of computers in the humanities and social sciences, the

> emphasis now seems to be on what the computer does best rather than on what students (and teachers) need. In fact, a substantial portion of microcomputer sales is based on the premise that future generations of students will need to understand the computer itself as the foundation of their success. From this central idea, apparently, come programs that teach foreign languages by drilling students on lists of vocabulary....That is, the machine's ability to present a question, to compare the answer to a stored response, and to present then a signal of approval or disapproval is utilized without any defense of the proposition that this is the preferred method of instruction. (1983, p. 25)

In short, without appropriate attention by teachers in the humanities, including foreign language teachers, we will once again find ourselves in a situation like that of the language laboratories, which were poorly used and supervised not by professors in the humanities but by inadequately paid assistants. Or we may replay the even less attractive situation of machine translation in 1963 when an external committee moved in to cut off all research activities, and pretty well did so.

Fortunately, if a bit tardily, the largest association of humanists in the country, the Modern Language Association, is taking action. Among a broad agenda is the establishment of national centers for language teaching. Even more happily, in spite of the problems with the federal budget, the new Title VI of the Higher Education Act authorizes the Department of Education "to make grants to institutes of higher education to establish and/or operate comprehensive language and area studies centers." The sum authorized for Title VI is $55 million. Less will probably be made available. Yet the seriousness of the intent may be indicated by the reduction of "the number of meetings per year of the Advisory Board from four to two" and the "number of Board members from 23 to 9."

Only through large national centers will the prime specialists be enabled to ensure up-to-date facilities for the use of computers in humanistic activities, comparable to those in the physical sciences and engineering, as an example in the teaching of languages may demonstrate. An illustration which I like to cite deals with the use of videotapes, a somewhat different technology but still not foreign to computer uses. In a series of persistent strokes of good fortune Professor Kimberly Sparks of Middlebury College was successful in persuading one of the German TV networks to provide him with a one half-hour program per week of their Walter Cronkhite newscast. Preparing these for presentation to an elementary group of

students required 24 hours of Professor Sparks's time for each half-hour program. Clearly, if such a useful undertaking were to be available throughout the country, including high schools and probably even outstanding elementary schools as well as universities, it would have to be managed from a national center which would assemble the specialists and arrange distribution, in an effort to make similar arrangements for French, Russian, Spanish, Portuguese, Hindi, Arabic, Chinese, Japanese, and so on. The same applies for capable computer software.

Looking a bit to the future, I draw on Joseph Deken's interesting book, *Silico Sapiens*. As robotics, whether or not it is the "ultimate technology," overtakes us (Deken, 1985/86, p. 223), we face once again the new terminology that comes with successive advances. Long ago we learned eventually that the second syllable of *software* was to be spelled like that of *hardware*, rather than like that of *underwear*, which may have been more appropriate. We also made our way through the age of the *breakthrough* to the age of *robustness*, which is still lingering in less with-it centers. The terminology of robotics is virtually an industry in itself. For designations of the various sizes of these creatures we have no trouble with *macrobot* for the monster that digs coal, or with *midrobot* for the variety that welds and paints your Corvette; but is it *microbot* as in Mickey, or *microbot* as in Mike, for the fellow that controls your Corvette's ignition system or for the device in your camera that does all the picture-taking and even tells you about it? Or, since there are *astrobots* and *geobots*, will *robot* herself become a *hydrobot* that competes with Oxford and Cambridge crews on the Thames? Karl Čapek not only gave us a shortened Czech word for puzzlement, but also a suffix rivalling *-burger* in proliferation, as anyone learns who fares forth to provide an appropriate Christmas for the younger set this year.

One prospective form of microbot is the realicorder, which Deken describes as a "robot descendant of the video and high-fidelity systems of the late twentieth century merged with computer *simulation* technology first developed (in extremely expensive and cumbersome form) for computerized aircraft flight trainers." As Deken points out, in the use of such trainers "the human is not simply a listener or viewer, but a *participant*" (1985/86, p. 31). Among proposed uses are "realicorder tours" where participants "will see exotic sights and sounds evolve as they choose an individual itinerary." Further, this device will make it unnecessary "to learn from lifeless books...[but teachers will be able to] summon up a wealth of native speakers and authentic sights and sounds of [differing cultures, say to learn] Russian on a realicorder 'guided tour' of Moscow" (1985/86, pp. 32-33). Those who have seen the language teaching facilities of well-supported schools like the Foreign Service Institute of the State Department know that these have long used models of places like Moscow set on tables around which four or five students discuss in Russian the local scene under the guidance of a fluent speaker/instructor. The realicorder will supplant such teaching through its lively presentation of "authentic sights and sounds" in which students will participate. Students of Chinese will learn control of

the Chinese language and culture through simulated tours of Peking. Similarly, students of Italian will have their tours of Rome, as will students of Latin through Rome at an earlier time. Students of Classical Greek will be able to have a dialogue with Socrates; students of Hittite will walk the streets of Boğazköy in 1400 B.C. The study of ancient languages and cultures will be on a totally new basis. Zgusta's *Kleinasiatische Personennamen* (1964) may be among the best-sellers in the year 2006.

But installation of the equipment and preparation of materials will be costly, when these are introduced into high schools and colleges, even if initially perhaps only in universities. Nonetheless, in view of current situations, such as our trade imbalance (caused at least in part by our ignorance of foreign languages and foreign cultures), or even of more tragic events, such as our entry into the Vietnam war or our long-standing inept policy in the Middle East, we would profit more from the development of computerized robots to teach foreign languages and foreign cultures than from determining the activity of the 247th electron of uranium as it rotates around the nucleus, or than from improved understanding of the weather on Mars, Jupiter, or even Earth. Because of such benefits it may even be possible to devote a small fraction of the sums assembled for Supercomputer installations like the Beckman Institute to the study and teaching of language, say $10 million per year. In this way the National Science Foundation might make up in part for its destructive report of twenty years ago which effectively blocked further computational linguistic activity. The Beckman Institute might also fulfill the hopes of the American Association for the Advancement of Science as a center for interdisciplinary research. And the National Endowment for the Humanities might finally recognize that activities in its sphere require funding for matters other than setting up summer seminars for inculcating the procedures of deconstructionism.

Leaning on Deken one last time, we may agree that "Human *natural language* is rich in all the aspects of vocabulary, syntax, and semantics, but for the present at least, it is far beyond the comprehension of robots" (1985/86, p. 148). How better could the Beckman Institute and the faculty of the University of Illinois at Urbana-Champaign, as well as the National Science Foundation, fulfill their aims than in developing the best possible means of teaching human students to teach today's computers and robots to become the more adept computers and robots who will serve the students of the future? Or will it be vice versa?

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